VALVE OPERATING SYSTEM IN AN INTERNAL COMBUSTION ENGINE

FIELD OF THE INVENTION

[0001] This invention generally relates to valve operating systems in internal combustion engines. More particularly, this invention relates to a valve operating system having a rocker arm connected to a ball and socket joint for operating a cylinder valve in an internal combustion engine.

BACKGROUND OF THE INVENTION

[0002] Internal combustion engines convert chemical energy from a fuel into mechanical energy. The fuel may be petroleum-based (gasoline or diesel), natural gas, another combustible material, or a combination thereof. Most internal combustion engines mix the fuel with air and then inject the air-fuel mixture into one or more cylinders formed by a crankcase, cylinder head, and piston. The internal combustion engine may use a camshaft system, a hydraulically activated electronically controlled unit injection (HEUI) system, or the like to control the injection of the air-fuel mixture into the cylinders. In each cylinder, the fuel ignites to generate rapidly expanding gases that actuate the piston. The fuel may be ignited by compression such as in a diesel engine or through some type of spark such as the spark plug in a gasoline engine. The piston usually is connected to a crankshaft or similar device for converting the reciprocating motion of the piston into rotational motion. The crankshaft also causes the piston to push the exhaust gases out of the cylinder during a return stroke, thus preparing the cylinder to receive more of the air-fuel mixture. The rotational motion from the crankshaft may be used to propel a vehicle, operate a pump or an electrical generator, or perform other work. The vehicle may be a truck, automobile, boat, or the like.

[0003] Most internal combustion engines have one or more exhaust valves connected to each cylinder. The exhaust valves typically open at the appropriate time to permit the exhaust gases to exit the cylinder. Many internal combustion engines have one or more inlet valves connected to each cylinder. The inlet valves typically open at the appropriate time to permit the air-fuel mixture to enter the cylinder.

[0004] Many internal combustion engines have a rocker arm assembly for operating the exhaust and inlet valves. The rocker arm assembly typically has separate rocker arms for each cylinder. Usually, there is one rocker arm for operating the exhaust valve(s) and another rocker arm for operating the inlet valve(s). The midsection of each rocker arm usually is mounted on the cylinder head of the internal combustion engine in such a way that the ends of the rocker arm articulate in opposite directions similar to a see-saw motion. One end of the rocker arm usually is connected to a push rod and/or camshaft mechanism. The other end of the rocker arm usually is connected to a valve activation device. During engine operation, the push rod moves or pushes one end of the rocker arm up thus causing the other end of the rocker arm to move or push down against the valve activation device. The valve activation device typically has a spring that biases the valve into a closed position. The pressure from the rocker arm causes the valve activation device to open the valve. When the push rod moves or pulls the end of the rocker arm down, the other end of the rocker arm to moves up or away from the valve activation device. Without the pressure of the rocker arm, the valve activation device closes the valve. When there are multiple valves, the rocker arm may connect to a valve bridge that is connected to the valve activation devices for each valve. The pressure from the rocker arm causes the valve bridge to press against the connected valve activation devices, thus opening the connected valves at substantially the same time. The rotational motion of the rocker arm against the valve activation device may cause wear of the components in contact. The rotational movement also may cause the rocker arm to slip where it contacts the valve activation device. This wear and slippage may affect engine operation, maintenance, and durability.

[0005] To reduce potential wear and slippage, many internal combustion engines use a rocker arm having a concave circular surface at the contact point with the valve activation device. Some internal combustion engines have a valve activation device with a convex circular surface. This convex circular surface may be configured to receive the concave circular surface of the rocker arm and thus form a ball and socket or similar type of connection. In addition, the contact point between the rocker arm and the valve or the valve bridge also may be lubricated.

[0006] In some internal combustion engines, the rocker arm and valve activation device are connected by a separate ball and socket joint. The ball typically has a pin extension on the opposite side of a concave circular surface. The pin extension has a conical or cylindrical

shape and is inserted into a hole formed in the end of the rocker arm. The socket has a convex surface on one side of that forms a cavity. The socket connects to the valve activation device on the side opposite the convex surface. When assembled, the ball is positioned inside the cavity of the socket so that the concave surface of the ball is adjacent to the convex surface of the socket. The ball and socket usually are held together by a retention mechanism such as a spring or a wire.

[0007] The ball and socket joint may be held together by a spring mounted on either side of radial flanges formed by the ball and socket. The ball may have a radial flange formed between the pin extension and the concave circular surface. The socket may have a radial flange formed along the entrance to the cavity. The spring typically is positioned on the sides of the flanges that are opposite to the concave and convex surfaces. The spring biases or presses the ball and socket together. The spring may increase the material and assembly costs of the ball and socket joint. The spring also may interfere with operation of the valves in the internal combustion engine. If the spring tension is too tight, the ball may not rotate as freely in the socket as desired for operation of the valves. If the spring tension is too loose, the spring may resist or oppose the movement of the rocker arm by the push pin. If the spring looses its resiliency or becomes stretched, it may extend into or beyond the interface between the flat surface of the socket and the valve or the valve bridge.

[0008] The ball and socket joint also may be held together by an O-ring positioned on the inside surface of the cavity formed by the socket. The O-ring usually is a wire positioned in a radial groove on the inside surface of the cavity. When the ball is inside the cavity, the O-ring is between the ball and the entrance to the cavity. The O-ring may increase the material and assembly costs of the ball and socket joint. The socket may have a deeper cavity to accommodate the inside groove and O-ring. If the ball is inserted into the socket after the O-ring is inserted into the inside groove, the ball may have to be forcibly inserted into the socket. This forcible insertion may damage the O-ring and the ball. If the O-ring is inserted into the groove after the ball is inserted into the socket, the socket may have an even deeper cavity so the O-ring can be positioned in the inside groove with less interference from ball. The O-ring also may obstruct the rotational movement of the ball in the socket. The O-ring may block the movement of the concave surface when the ball rotates. The pin extension may strike the side of a cavity.

[0009] The ball and socket joint additionally may be held together by a metal or plastic ring that encompasses both parts. The ring may interfere with the rotational motion of the ball in the socket. The ring may become loose and interfere with the interface between the socket and the valve activation devices. The ring also may reduce or block lubrication fluid from reaching the ball and socket joint.

[0010] The ball and socket joint further may be held together by a folded radial edge or lip along the inside of the entrance to the cavity in the socket. If the ball is inserted into the socket after the radial edge is folded, the ball may have to be forcibly inserted into the socket. The forcible insertion may damage the radial edge and the ball. The radial edge may obstruct the rotational movement of the ball in the socket. The radial edge may block the movement of the concave surface when the ball rotates. The pin extension may strike the radial edge

SUMMARY

[0011] This invention provides a valve operating system for an internal combustion engine. The valve operating system has a ball and socket joint with a retention device positioned in an external groove on the ball and socket joint. The retention device holds the ball and socket joint together.

[0012] A valve operating system for an internal combustion engine may have a rocker arm, a rocker actuation mechanism, a ball and socket joint, and a valve activation device. The rocker arm is connected to the rocker actuation mechanism and to the ball and socket joint. The ball and socket joint has a retention device connected to a ball portion and a socket portion. The retention device is positioned in an external groove formed by the socket portion. The ball portion is connected to the rocker arm. The valve activation device is connected to the socket portion.

[0013] A ball and socket joint for a valve operating system in an internal combustion engine may have a ball portion, a socket portion, and a retention device. The ball portion has a flange between a pin extension and an interface surface. The socket portion has a foot extension and forms a cavity with an interior surface. The socket portion forms an exterior groove between the foot extension and an entrance to the cavity. The retention device has a pin segment connected to a foot segment. The pin segment forms a pin loop. The foot segment forms a foot loop. The interface surface of the ball portion is positioned adjacent to

the interior surface in the cavity of the socket portion. The pin extension is disposed in the pin loop. The pin segment is adjacent to the flange. The socket portion is disposed in the foot loop. The foot segment is positioned in the external groove.

[0014] An internal combustion engine with a valve operating system may have a cylinder head mounted on a crankcase, a valve, a rocker arm, a rocker actuation mechanism, a ball and socket joint, and a valve activation device. The cylinder head and the crankcase form a cylinder. The cylinder head forms a valve path connected to the cylinder. The valve is disposed within the valve path. The rocker arm is mounted on the cylinder head. The rocker actuation mechanism is connected to the rocker arm. The ball and socket joint has a retention device connected to a ball portion and a socket portion. The retention device is positioned in an external groove formed by the socket portion. The ball portion is connected to the rocker arm. The valve activation device is connected to the socket portion. The valve activation device is connected to the valve.

[0015] Other systems, methods, features and advantages of the invention will be, or will become, apparent to one with skill in the art upon examination of the following figures and detailed description. It is intended that all such additional systems, methods, features and advantages be included within this description, be within the scope of the invention, and be protected by the following claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The invention can be better understood with reference to the following drawings and description. The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention. Moreover, in the figures, like referenced numerals designate corresponding parts throughout the different views.

[0017] FIG. 1 is a schematic cross-section view of a valve operating system in an internal combustion engine.

[0018] FIG. 2 is a front view of a ball and socket joint for a valve operating system.

[0019] FIG. 3 is a back view of the ball and socket joint shown in FIG. 2.

[0020] FIG. 4 is a top view of the ball and socket joint shown in FIG. 2.

[0021] FIG. 5 is a bottom view of the ball and socket joint shown in FIG. 2.

[0022] FIG. 6 is an expanded front view of the ball and socket joint shown in FIG. 2.

[0023] FIG. 7 is a back view of the retention device shown in FIG. 6.

[0024] FIG.8 is a side view of another ball and socket joint for a valve operating system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] FIG. 1 is a schematic cross-section view of a valve operating system 102 in an internal combustion engine. The valve operating system 102 may have a rocker actuation mechanism 104, a rocker arm 106 mounted on a base 108, a ball and socket joint 110, and a valve activation device 112. The rocker actuation mechanism 104 is connected to one end of the rocker arm 106. The rocker actuation mechanism 104 may be a camshaft, a pushrod connected to a camshaft, or the like. The ball and socket joint 104 is connected to the other end of the rocker arm 106 and to the valve activation device 112. The ball and socket joint 110 has an exterior indentation or groove for holding a retention device. The ball and socket joint 110 may have a portion configured for insertion into a hole formed by the rocker arm 106. The base 108 of the valve operating system 102 may be connected to a cylinder head 120 or other component of the internal combustion engine. The cylinder head 120 is mounted on a crankcase 122, which forms a cylinder 128. The cylinder 128 has a piston 130 disposed therein. The cylinder 128 also has a valve 124 disposed within a valve path 132 formed by the cylinder head 122. The valve 124 may be an inlet valve for allowing an air-fuel mixture to enter the cylinder 128. The valve 124 may be an exhaust valve for allowing exhaust gases to exit the cylinder 128. The valve 124 is connected to the valve activation device 112 that opens and closes the valve 124. When no pressure is applied, the valve activation device 112 may bias or otherwise maintain the valve in a closed position. When pressure is applied, the valve activation device 112 may move the valve into an opened position. The valve activation device 112 may include a valve bridge for connecting the ball and socket joint 110 to multiple valves 124. While a particular configuration is shown, the valve operating mechanism may have other configurations including those with fewer or additional components.

[0026] The internal combustion engine may be a gasoline engine, a diesel engine, or the like. The internal combustion engine may be a diesel engine with a hydraulically activated electronically controlled unit injection (HEUI) fuel system. The internal combustion engine may have six, eight, or another number of cylinders. The internal combustion engine may

have other components (not shown) such as a fuel injector for each cylinder, pumps, an engine cooling system, and the like. The internal combustion engine may have multiple valve operating systems 102, which may be combined to form a rocker arm assembly or the like. The internal combustion engine may have two or more valve operating systems 102 for each cylinder 128. The internal combustion engine may have one or more valve bridges 126; each connected to operate a set of like valves, such as the inlet valves or the exhaust valves of a cylinder, at substantially the same time.

[0027] During operation of the valve operating system 102, the rocker actuation mechanism 104 moves one end of the rocker arm 106 in an up-and-down motion. This movement rotates the rocker arm 106 at the base 108, thus moving the other end of the rocker arm 106 in the opposite direction. When the rocker actuation mechanism 104 moves one end of the rocker arm 106 in an up direction, the other end of the rocker arm 106 presses the ball and socket joint 110 against the valve activation device 112 to open valve 124. When the rocker actuation mechanism 104 moves one end of the rocker arm 106 in a down direction, the other end of the rocker arm 106 moves the ball and socket joint 110 away from the valve activation device 112 to close valve 124. Up-and-down motion includes side-to-side and other opposite motion movements.

[0028] Figs. 2-7 show various views of a ball and socket joint 210 and its components. The ball and socket joint 210 has a ball portion 260, a socket portion 270, and retention device 280. The ball portion 260 is configured to rotate or move within the socket portion 270. The retention device 280 holds the ball portion 260 and the socket portion 270 together. The ball portion 260 may be connected to a rocker arm of a valve operating system. The socket portion 270 may be connected to a valve activation device of a valve operating system. The ball and socket joint 210 may be made of metal, plastic, and the like, or a combination thereof. The ball and socket joint 210 may be made of an elastomeric material.

[0029] The ball portion 260 has a pin extension 262, an interface surface 264, and a flange 266. The pin extension 262 is on a side opposite the interface surface 264. The flange 266 extends radially along the circumference of the ball portion 260 at a position between the pin extension 262 and the interface surface 264. The flange 260 may have a circular or angular shape. Circular includes circles, ovals, and like shapes. Angular includes triangle, rectangle, and like shapes. The pin extension 262, the interface surface 264, and the flange 266 may have the same centerline or different centerlines. The centerlines may be off-center

or at an angle to each other. The pin extension 262 may have a cylindrical, pyramidal, or conical configuration. The pin extension 262 may be configured for insertion into a hole formed by a rocker arm in a valve operating mechanism. The pin extension 262 may have a smaller cross-section than the flange 266. The interface surface 264 may have a circular or other concave shape. The interface surface 264 may have the same or a smaller cross-section than the flange 266.

[0030] The socket portion 270 forms a cavity 272 with an entrance or opening 274 at one end. The socket portion 270 has a foot segment 276 that extends radially from the exterior surface of the socket portion 270. The foot segment may be at or toward the end opposite the entrance 274. The cavity 272 is formed by an interior surface, which may have a circular or other convex surface. The cavity 272 may be configured to receive the interface surface 264 of the ball portion 260. The surface of the cavity 272 may be configured to follow the pattern the interface surface 264. The socket portion 270 also forms an indentation or groove 278 that runs along the exterior circumference of the socket portion 270 between the entrance 274 and the foot segment 276. The socket portion 270 may have a smaller cross-section at the exterior groove 278 than at the entrance 274 to the cavity 272. The socket portion 270 also may have a smaller cross-section at the exterior groove 278 than at the foot segment 276.

[0031] The retention device 280 has a bridge segment 282 connecting a pin segment 284 to a foot segment 286. The pin segment 284 and the foot segment 286 extend tangentially from the bridge segment 282. Tangentially includes partially or substantially tangent. The bridge segment 282 may have a flat, curvilinear, wavy, or angular shape. The retention device 280 may be made from spring steel or another malleable material. The retention device 280 also may be made from a thermoplastic or another semi-rigid or rigid material.

[0032] The pin segment 284 forms a pin loop 288. The cross-section of the pin loop 288 is greater than or equal to the cross-section of the pin extension 262. The cross-section of the pin loop 288 is less than the cross-section of the flange 266. The pin segment 284 may have a tail portion 292 that alters the direction of the pin segment 284.

[0033] The foot segment 286 forms a foot loop 290. The cross section of the foot loop 290 may be greater than or equal to the cross-section of the socket portion 270 at the exterior groove 278. The cross section of the foot loop 290 may be less than the cross-section of the

socket portion 270 at the foot segment 276. The cross section of the foot loop 290 also may be less than the cross-section of the socket portion 270 at the entrance 274 to the cavity 272.

[0034] When assembled, the retention device 280 holds the ball portion 260 and the socket portion 270 together with the interface surface 264 positioned adjacent to the interior surface of the cavity 272. The pin extension 262 is positioned inside the pin loop 288 with the pin segment 284 disposed adjacent to the flange 266 on the side opposite the interface surface 264. The pin segment 284 may extend partially or fully along the circumference of the pin extension 262. The socket portion 270 is positioned inside the foot loop 290 with the foot segment 286 disposed within the exterior groove 278. The foot segment 286 may extend partially or fully along the circumference of the socket portion 870 at the exterior groove 278. The retention device 280 may be formed by bending and wrapping a wire or like material around the ball portion 260 and the socket portion 270. The retention device 280 may be formed first for insertion of the ball portion 260 and socket portion 270 into their positions. The flange 266 of the ball portion 260 may have a smaller cross-section than the foot loop 290 so that the ball portion 260 may pass through the foot loop 290 when the pin extension 262 is inserted in the pin loop 288.

[0035] FIG. 8 shows another a ball and socket joint 810 having has a ball portion 860, a socket portion 870, and retention device 880. The ball portion 860 is configured to rotate or move within the socket portion 870. The retention device 880 holds the ball portion 860 and the socket portion 870 together. The ball portion 860 may be connected to or inserted in a rocker arm in a valve operating system. The socket portion 870 may be connected to a valve or valve bridge for a cylinder of an internal combustion engine. The ball portion 860 is essentially the same as the ball portion previously discussed. The ball portion 860 has a pin extension 862, an interface surface, and a flange 866. The socket portion 870 is essentially the same as the socket portion previously discussed. The socket portion 870 forms a cavity with an entrance or opening 874 at one end and a foot segment 876 at the opposite end. The socket portion 870 also forms an exterior groove 878 between the entrance 874 and the foot segment 876. The retention device 880 is essentially the same as the retention device previously discussed except for the pin segment. The retention device 880 has a bridge segment 882 between a pin segment 884 and a foot segment 886. The foot segment 886 forms a foot loop 890. The pin segment 884 forms a plurality of windings around the pin extension 862. A plurality of windings includes any number of windings and partial

windings greater than about one winding. The plurality of windings form multiple pin loops, which may have the same or different cross-sections. The multiple windings may create a spring-like or bias effect to hold the ball portion 860 against the socket portion 870.

[0036] While various embodiments of the invention have been described, it will be apparent to those of ordinary skill in the art that other embodiments and implementations are possible within the scope of the invention. Accordingly, the invention is not to be restricted except in light of the attached claims and their equivalents.